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B HADRON DECAYS AND RESONANCES AT D0

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Using D0 data collected at Tevatron collider since april 2002, new measurements of excited B_d^0 and B_s^0 mesons decays properties are presented. Searches for rare B_s^0 decay channels are summarized with expected limits on their production rate. The study of the $B_s^0 \rightarrow J/\psi\phi$ decay is performed to obtain the B_s^0 lifetime as well as some others characteristics of the ($B_s^0, \bar{B_s^0}$) system.

Theoretical quark models relating to the spectroscopy of B_d^0 (and B_s^0 mesons)[1] predicts the existence of two excited narrow P states denoted B_1 and B_2^* (B_{s1} and B_{s2}^* respectively) which have never been observed unambigously. Those states should decay through a D wave (L=2) with a small width of around 10 MeV. Using an integrated luminosity of 1 fb^{-1}, the D0 experiment studied the reconstructed B_1 and B_2^* states through the following decays: ($B_1^0 \rightarrow B^{*+}\pi^-$, $B^{*+} \rightarrow B^+\gamma$), ($B_2^{0*} \rightarrow B^{*+}\pi^-$, $B^{*+} \rightarrow B^+\gamma$) and ($B_2^{0*} \rightarrow B^+\pi^-$). The final decay product of the B^{*+} meson is a B^+ with a release of an undetected photon of $45.78 \pm 0.35\ MeV$. The B^+ mesons are reconstructed in the exclusive decay: $B^+ \rightarrow J/\psi K^+$ with J/ψ decaying to $\mu^+\mu^-$. The selection of the 16219 ± 180 B^+ candidates is based on the presence of two identified muons correctly associated with a kaon track. By means of a likelihood ratio method, the B_J selection is achieved by requiring an additionnal track originating from the primary vertex with a correct pion charge correlation . The distribution of the mass difference given by $\Delta M = M(B^+\pi^-) - M(B^+)$ and fitted with a binned likelihood function (described by the convolution of a relativistic Breit-Wigner with the experimental resolution on ΔM) can be interpreted in terms of B_J transitions as illustrated in Fig. 1. The B_1 and B_2^* mesons are observed for the first time as two separate states and their masse and their average width (set equal in the fit) were measured to be: $M(B_1) = 5720.8 \pm 2.5(stat) \pm$

$5.3(sys)\ MeV$, $M(B_2^*) - M(B_1) = 25.2 \pm 3.0 \pm 1.1\ MeV$, $\Gamma(B_1) = \Gamma(B_2^*) = 6.6 \pm 5.3 \pm 4.2\ MeV$. The branching ratio of B_2^* to the excited state B^* was fitted as $Br(B_2^* \to B^*\pi)/Br(B_2^* \to B^{(*)}\pi) = 0.513 \pm 0.092 \pm 0.115$. The branching ratio of the B_J sample in the state B_1 was measured as $Br(B_1 \to B^*\pi)/Br(B_J \to B^{(*)}\pi) = 0.545 \pm 0.064 \pm 0.071$. Finally, the B_J is measured as a fraction of the B^+ rate with $0.165 \pm 0.024 \pm 0.028$.

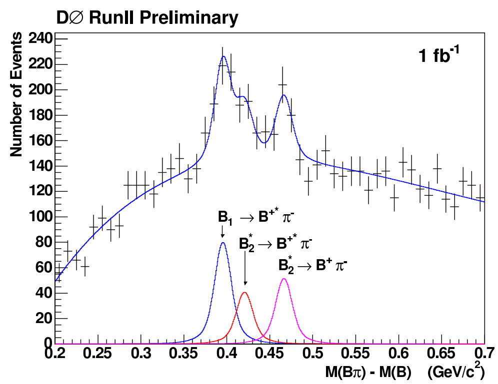

Figure 1. Mass difference $\Delta M = M(B^+\pi^-) - M(B^+)$ for exclusive B decays with the corresponding 3 peaks shown separately.

The analysis of B_{sJ} states decaying to B^+K^- is very similar to the previous one, changing the kaon mass assignation to the additional track. Fig. 2 shows the first direct observation of the B_{s2}^* signal with a significance greater than 5 and a fitted mass $M(B_{s2}^*) = 5839.1 \pm 1.4 \pm 1.5\ MeV$.The absence of the B_{s1} signal is due to the short mass difference between the B_{s2}^* signal and the kinematical constraint $M(B_{s1}) < M(B^{+*}) - M(K^-)$.

The decay $B_s^0 \to \mu^+\mu^-(\phi)$ is an FCNC process forbidden in the Standard Model at tree level which proceeds at a very low rate in higher order diagrams ($Br_{SM} \sim 10^{-9}$). D0 performs a blind analysis with 700 pb^{-1} based on the search for a secondary 3D-vertex built from two oppositely charged tracks and some requirements on discriminating variables. The signal was optimized with a random grid search method. In the $\mu^+\mu^-$ invariant mass signal region 4 events compatible with the expected background were found after selection . Using the $B^+ \to J/\psi K^+$ process as a normalisation channel, D0 obtains the branching ratio limit $Br(B_s^0 \to \mu^+\mu^-) < 2.3.10^{-7}$ at 95% CL. For the $B_s^0 \to \mu^+\mu^-\phi$ decay channel, the limit on the branching ratio is $4.1.10^{-6}$ at 95% CL for 300 pb^{-1}.

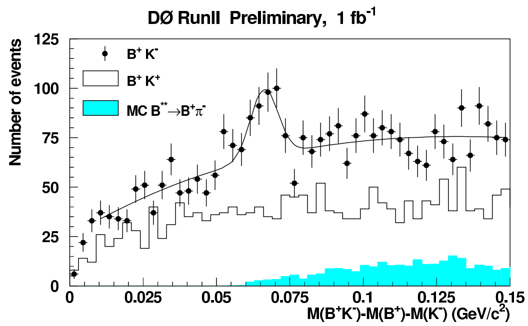

Figure 2. Mass difference $\Delta M = M(B^+K^-) - M(B^+) - M(K^-)$ for exclusive B decay. The histogram shows the mass difference for B^+K^+. The solid histogram represents the MC distibution of the decay $B^{**} \to B^{(*)}\pi$ where the π is misidentified as a kaon.

In the Standard Model, the mass eigenstates of B_s^0 mesons (B_s^H and B_s^L) are linear combinations of flavor eigenstates and also approximately CP eigenstates. Defining $\Delta m = m_H - m_L$, $\Delta\Gamma = \Gamma_L - \Gamma_H$ and $\Gamma = (\Gamma_H + \Gamma_L)/2$, B_s^0 mesons are produced in an equal mixture of B_H and B_L and their decay length is described by $exp(-\Gamma_H t) + exp(-\Gamma_L t)$ instead of $exp(-\Gamma t)$ (assuming a single lifetime). The first analysis reconstructs the semileptonic decay channel $B_s^0 \to D_s^- \mu^+ \nu X,\ D_s^- \to \phi\pi^-,\ \phi \to K^+K^-$ using a 400 pb^{-1} data sample. The pseudo-proper decay length defined as $L_{xy} m(B_s^0)/P_T(D_s^- \mu^+)$ (where L_{xy} is the transverse decay length) is fitted by means of an unbinned maximum likelihood method under the assumption of a single-exponential decay and leads to the B_s lifetime results (Fig. 3) : $\tau(B_s^0) = 1.398 \pm 0.0044(stat)^{+0.028}_{-0.025}(sys)\ ps$. The result is in good agreement with previous experiments and the current world average value. The second analysis studied the decay chain $B_s^0 \to J/\psi,\ J/\psi \to \mu^+\mu^-,\ \phi \to K^+K^-$ which gives rise to both CP-odd and CP-even final states. Therefore, a simultaneous unbinned maximum likelihood fit to the B_s^0 candidate mass, the pseudo-proper decay length and 3 decay angles describing the angular distribution of both J/ψ and ϕ final states in transversity basis allows us to separate the two CP components and measure $\Delta\Gamma$ as illustrated in Fig. 4.With 0.8 fb^{-1} and in the limit of no CP violation, the preliminary results illustrated in Fig. 4 yield to $\Delta\Gamma = 0.15 \pm 0.10^{+0.03}_{-0.04}\ ps^{-1}$ and the average B_s^0 lifetime: $\bar{\tau}(B_s^0) = 1.53 \pm 0.08(stat)^{+0.01}_{-0.04}(sys) ps$. The fitted CP violating interference term is consistent with no CP violation violation in the $(B_s^0, \bar{B}_S^0)$ system.

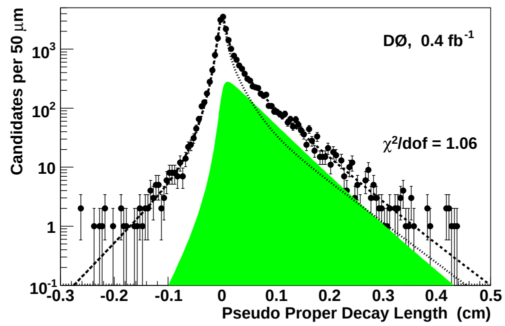

Figure 3. Pseudo-proper decay length distribution for $D_s^-\mu^+$ candidates with the superimposed fit (dashed curve), combinatorial background (dotted curve) and B_s signal (filled area).

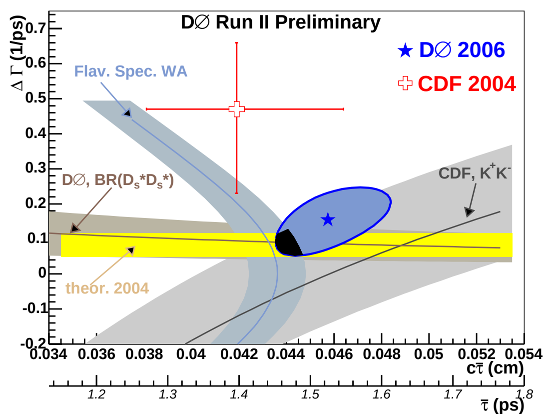

Figure 4. The 1-σ (stat) contour for the three angle fit in $\Delta\Gamma$ vs $c\bar{\tau}$ plane compared to the 1-σ band for the world average and the SM prediction (horizonthal band) [2]. Also shown are the CDF 2004 results [3] and the recent CDF measurement from $B_s \to K^+K^-$.

References

1. M. Di Pierro and E. Eichten, *Phys. Rev.* **D64**,(2001) 114004 [arXiv:hep-ph/0104208].
2. S. Eidelman *et al*, Particle Data Group, *Phys. Lett. B* **592**, 1 (2004).
3. CDF Collaboration, *Phys. Rev. Lett.* **94**, 101803 (2005).